BIG IDEAS

Reactants must collide to react, and the **reaction rate** is dependent on the surrounding conditions.	**Dynamic equilibrium** can be shifted by changes to the surrounding conditions.	**Saturated solutions** are systems in equilibrium.	**Acid or base strength** depends on the degree of ion dissociation.	**Oxidation and reduction** are complementary processes that involve the gain or loss of electrons.

Learning Standards

Curricular Competencies	Content
Students are expected to be able to do the following: **Questioning and predicting** • Demonstrate a sustained intellectual curiosity about a scientific topic or problem of personal, local, or global interest • Make observations aimed at identifying their own questions, including increasingly abstract ones, about the natural world • Formulate multiple hypotheses and predict multiple outcomes **Planning and conducting** • Collaboratively and individually plan, select, and use appropriate investigation methods, including field work and lab experiments, to collect reliable data (qualitative and quantitative) • Assess risks and address ethical, cultural, and/or environmental issues associated with their proposed methods • Use appropriate SI units and appropriate equipment, including digital technologies, to systematically and accurately collect and record data • Apply the concepts of accuracy and precision to experimental procedures and data: – significant figures – uncertainty – scientific notation **Processing and analyzing data and information** • Experience and interpret the local environment	*Students are expected to know the following:* • **reaction rate** • **collision theory** • **energy change** during a chemical reaction • **reaction mechanism** • **catalysts** • **dynamic nature of chemical equilibrium** • **Le Châtelier's principle and equilibrium shift** • **equilibrium constant (K_{eq})** • saturated solutions and **solubility product (K_{sp})** • **relative strength** of acids and bases in solution • water as an equilibrium system • **weak acids and weak bases** • **titration** • **hydrolysis of ions in salt solutions** • **applications of acid-base reactions** • **the oxidation-reduction process** • **electrochemical cells** • **electrolytic cells** • **quantitative relationships**

Learning Standards (continued)

Curricular Competencies	Content
• Apply First Peoples perspectives and knowledge, other ways of knowing, and local knowledge as sources of information • Seek and analyze patterns, trends, and connections in data, including describing relationships between variables, performing calculations, and identifying inconsistencies • Construct, analyze, and interpret graphs, models and diagrams • Use knowledge of scientific concepts to draw conclusions that are consistent with evidence • Analyze cause-and-effect relationships **Evaluating** • Evaluate their methods and experimental conditions, including identifying sources of error or uncertainty, confounding variables, and possible alternative explanations and conclusions • Describe specific ways to improve their investigation methods and the quality of their data • Evaluate the validity and limitations of a model or analogy in relation to the phenomenon modelled • Demonstrate an awareness of assumptions, question information given, and identify bias in their own work and in primary and secondary sources • Consider the changes in knowledge over time as tools and technologies have developed • Connect scientific explorations to careers in science • Exercise a healthy, informed skepticism and use scientific knowledge and findings to form their own investigations to evaluate claims in primary and secondary sources • Consider social, ethical, and environmental implications of the findings from their own and others' investigations • Critically analyze the validity of information in primary and secondary sources and evaluate the approaches used to solve problems • Assess risks in the context of personal safety and social responsibility	

Learning Standards (continued)

Curricular Competencies	Content
Applying and innovating • Contribute to care for self, others, community, and world through individual or collaborative approaches • Co-operatively design projects with local and/or global connections and applications • Contribute to finding solutions to problems at a local and/or global level through inquiry • Implement multiple strategies to solve problems in real-life, applied, and conceptual situations • Consider the role of scientists in innovation **Communicating** • Formulate physical or mental theoretical models to describe a phenomenon • Communicate scientific ideas and information, and perhaps a suggested course of action, for a specific purpose and audience, constructing evidence-based arguments and using appropriate scientific language, conventions, and representations • Express and reflect on a variety of experiences, perspectives, and worldviews through **place**	

Big Ideas – Elaborations

- **reaction rate:**
  Sample questions to support inquiry with students:
  - What factors influence the way reactant molecules, atoms, and ions collide?
  - How does collision theory explain reaction rate?
- **Dynamic equilibrium:**
  Sample question to support inquiry with students:
  - What are the conditions that can affect equilibrium?
- **Saturated solutions:**
  Sample questions to support inquiry with students:
  - How is the solubility constant useful in studying chemical processes?
  - How can ions (e.g., calcium, magnesium) be removed from hard water?
- **Acid or base strength:**
  Sample questions to support inquiry with students:
  - How are the concepts of acid/base strength and acid/base concentration different?
  - How can acid/base dissociation be measured?
  - How are acid and base systems in equilibrium?
  - How are aquatic ecosystems affected by changes in pH?
- **Oxidation and reduction:**
  Sample questions to support inquiry with students:
  - How can electrochemical and electrolytic cells be used in practical situations?
  - What are some applications of redox reactions?

- **Questioning and predicting:**
  Sample opportunities to support student inquiry:
  - What observable properties would you use to determine a reaction rate?
  - Observe catalyzed reactions, such as
    - decomposition of hydrogen peroxide, catalyzed by MnO_2
    - decomposition of bleach, catalyzed by $CoCl_2$
    - autocatalysis of oxalic acid and $KMnO_4$
  - Predict qualitative changes in the solubility equilibrium upon the addition of a common ion or the removal of an ion.
- **Planning and conducting:**
  Sample opportunities to support student inquiry:
  - Determine the rate of a reaction through experimentation.
  - Identify an unknown ion through experimentation involving a qualitative analysis scheme.
  - Devise a method for determining the concentration of a specific ion by titration or gravimetric methods (e.g., concentration of chloride ion using a precipitation reaction with silver ion).
  - Design, perform, and analyze a titration experiment involving:
    - primary standards
    - standardized solutions
    - titration curves
    - appropriate indicators
    - proper technique
  - Prepare a buffer system.
  - From data for a series of simple redox reactions, create a simple table of reduction half-reactions.
  - Construct an electrochemical cell. Determine the half-reactions that take place at each electrode, the overall reaction, and the resulting mass of the electrodes.
  - Design and label the parts of an electrolytic cell:
    - used for the electrolysis of a molten binary salt (e.g., $NaCl_{(l)}$)
    - capable of electrolyzing an aqueous salt (e.g., $KI_{(aq)}$, not requiring the use of overpotential effect)
    - used to electroplate an object
- **Processing and analyzing data and information:**
  Sample opportunities to support student inquiry:
  - Research the types of materials that are present in clay deposits traditionally used to treat skin conditions.
  - Compare and contrast factors affecting the rates of both homogeneous and heterogeneous reactions.

- Predict, with reference to entropy and enthalpy, whether reacting systems will reach equilibrium when:
  - both favour products
  - both favour reactants
  - they oppose each other
- Calculate the rate of a reaction using experimental data.
- Draw and label PE diagrams for both exothermic and endothermic reactions, including ΔH, activation energy, and the energy of the activated complex.
- Use a KE distribution curve to explain how changing the temperature or adding a catalyst changes the rate of a reaction.
- Interpret titration curves plotted from experimental data.

- **Evaluating:**
  Sample opportunities to support student inquiry:
  - Explore variables and assumptions (e.g., cost, demand, location, environmental considerations) to evaluate the feasibility of bringing a chemical industrial process to your local area.
  - Explore chemistry-related careers (e.g., chemical engineer, clinical biochemist, pharmacologist, environmental consultant, patent attorney, science writer).
- **Applying and innovating:**
  Sample opportunity to support student inquiry:
  - Investigate how green chemistry is used to reduce or eliminate the use or generation of hazardous substances in commercial chemical processes (e.g., production of pharmaceuticals, paints, plastics).
- **Communicating:**
  Sample opportunity to support student inquiry:
  - Cooperatively plan and present a chemistry-related project to an interested or simulated stakeholder group such as:
    - an industrial process (e.g., electrolytic refining, hydrogen fuel cells)
    - an environmental concern (e.g., ozone layer depletion, mine-waste-water remediation, carbon sequestration, the ocean as a carbon sink)
    - a biochemical equilibrium process (e.g., blood chemistry)
- **place:** Place is any environment, locality, or context with which people interact to learn, create memory, reflect on history, connect with culture, and establish identity. The connection between people and place is foundational to First Peoples perspectives.

- **reaction rate:**
  - heterogeneous and homogeneous reactions
  - factors that affect reaction rate
  - controlling reaction rate
- **collision theory:**
  - collision geometry
  - relationship between successful collisions and reaction rate
  - relationship of activated complex, reaction intermediates, and activation energy to PE diagrams
- **energy change:** relationship between PE, KE, enthalpy (ΔH), and catalysis
- **reaction mechanism:**
  - relationship of the overall reaction to a series of steps (collisions)
  - rate-determining step
- **catalysts:** applications (e.g., platinum in automobile catalytic converters, catalysis in the body, chlorine from CFCs in ozone depletion)
- **dynamic nature of chemical equilibrium:** reversible nature of reactions, relationship to PE diagram
- **Le Châtelier's principle and equilibrium shift:**
  - concentrations of reactants and products
  - enthalpy and entropy
  - presence of a catalyst
  - applications (e.g., Haber process, hemoglobin and oxygen in the blood)
- **equilibrium constant (K_{eq}):**
  - homogeneous and heterogeneous systems
  - pure solids and liquids
  - effect of changes in temperature, pressure, concentration, surface area, and a catalyst
- **solubility product (K_{sp}):** K_{sp} as a specialized K_{eq} expression
- **relative strength:**
  - electrical conductivity
  - table of relative acid strength
  - equations of strong and weak acids and bases in water
- **weak acids and weak bases:** equilibrium systems
- **titration:** the method to find an equivalence point:
  - strong acid–strong base titration

  - weak acid–strong base titration
  - strong acid–weak base titration
- **hydrolysis of ions in salt solutions:**
  - acidic, basic, or neutral salt solutions
  - amphiprotic ions
- **applications of acid-base reactions:**
  - non-metal and metal oxides in water and associated environmental impacts
  - buffers
- **the oxidation-reduction process:**
  - oxidation number
  - balancing redox reactions
- **electrochemical cells:** half-reactions, cell voltage (E^0), applications (e.g., lead-acid storage batteries, alkali cells, hydrogen-oxygen fuel cells)
- **electrolytic cells:** half-reactions, minimum voltage to operate, applications including metal refining (e.g. zinc, aluminum), preventing metal corrosion (cathodic protection)
- **quantitative relationships:** quantitative problems using relationships between variables such as:
  - in equilibrium systems (e.g., K_{eq}, initial concentrations, equilibrium concentrations)
  - in solutions (e.g., K_{sp}, prediction of precipitate formation, calculating the maximum allowable concentration)
  - in water as an equilibrium system (e.g., K_w, $[H_3O^+]$ or $[OH^-]$, pH and pOH)
  - in acid-base systems (e.g., K_a, K_b, $[H_3O^+]$, $[OH^-]$, pH and pOH)
  - in a titration (e.g., pH of a solution, K_a of an indicator)
  - pH in hydrolysis of ions in salt solutions
  - in a redox titration (e.g., grams, moles, molarity)
  - in an electrochemical cell (e.g., E^0)